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Spark Suppressor: A Fire Fighting Robot Using IOT

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ABSTRACT

Fire can break out at any place for ex (at home, in offices, factories, or public spaces) mostly without warning, causing damage to life and property. Fast and impactful fire suppression is Essential, but traditional firefighting methods can be week and put human lives at danger. The **"Spark Suppressor"** is a smart fire-fighting robot designed to provide a sharp, automatic solution for fire emergencies. This robot can find, see, and blow out fire either on its own or through remote operation. Using smart sensor, cloud-based tracking, and automatic blow out techniques, the Spark Suppressor provides a dependable and productive way to control fire before they increase. By implementing IOT frameworks, this system allows dynamic data collecting, remote tracking, and timely response, making firefighting enhanced safety and effectiveness in domestic and industrial environment. This robot is equipped to identify, track, and suppress fire independently or via remote operation. It uses advanced sensing and automated extinguishing technology to promptly control fire incidents, reducing the risk of damage. The IOT integration allows real-time data collection, remote access, and faster decision-making, making fire suppression more efficient and reducing human exposure to dangerous conditions. The system is suitable for residential and industrial applications, offering an advanced, run on technology approach to fire safety.

This paper explores the working mechanism of the **Spark Suppressor**, detailing its hardware and software components, IOT-based implementation, and its role in modernizing firefighting techniques. On top of that results looked good, it discusses the potential advantages of this autonomous system in various real-world applications and highlights future improvements such as AI-based fire prediction and drone-assisted fire suppression.

Keywords: Fire fighting robot, Autonomous Navigation, Indoor environment robotics, Fire Suppression, Hazard Response, Real-Time Alert, Remote Monitoring, Live Streaming

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1. Introduction

Fire outbursts are uncontrolled and dangerous primarily leading to serious harm to life, property and nature. Traditional fire extinguishing system was based on human intervention, which is time-consuming and risk-prone for firefightings. In order to ensure safety and efficiency, more and more demands are placed for smart, autonomous fire extinguishing systems to operate either independently or remotely controlled.

The "Spark Suppressor" is an IOT-based firefighting robot capable of detecting and suppressing fires effectively. It is a six-wheeled robot equipped with intelligent sensors, including a flame sensor to detect fire and an MQ2 gas sensor to sense dangerous gases. The robot is controlled via a local host website, which enables users to move the robot forward, backward, left, and right. The system is equipped with ESP32-CAM for streaming live video, making remote monitoring a reality.

On detecting fire, the flame sensor instantly activates a water pump to extinguish the fires. When the gas sensor detects harmful gases, a buzzer alarm is sounded every 20 seconds to alert individuals within the surrounding area. IOT technology application allows real-time collection of data, remote access, and automated response systems, making the Spark Suppressor a reliable and modern solution for domestic, industrial, and commercial fire emergencies.

Fire accidents are unexpected and can lead to widespread destruction of life and property. Traditional fire-fighting techniques are marred by delay and exposure of human firefighters. To overcome this, the "Spark Suppressor" is an IOT-based firefighting robot that is designed for real-time fire detection, monitoring, and extinguishing. With smart sensors, an ESP32-CAM for live video streaming, and a remote setup, it can be operated manually or remotely by a web interface. The flame sensor activates a water pump on fire, and the gas sensor triggers a buzzer alarm every 20 seconds in the event of toxic gases. This automated system provides quick response, safety, and efficiency, thus an appropriate solution for household, industrial, and business fire incidents. This essay discusses the design, construction, working mechanism, and advantages of the Spark Suppressor, and how it can be a game-changer in fire safety through IOT and automation.

So, firefighting robots will transform how we approach crises since their technology enable us to decentralize many strategies with focus on dousing fires and encountering danger.

Their operations a complete mission all without some kind of human agency, conducting situations of threat of life, and saving lives places these robots squarely in guarding the lives of people, property, and our global environment. As technology advances, these autonomous robot devices will be intelligent, faster, and more agile which will secure them in being a significant resource when responding to fire accidents. The use of AI, the internet of things, and real-time analytics will make them stronger in terms of capabilities to position them as pioneers in fire protection and emergency services.

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2. Problem Statement

This research project deals with the growing seriousness and frequency of fires in different regions which are a problem alone when it comes to human firefighters battling the aggressors. Fires related to commercial, industrial, and residential activities often result in large environmental loss and damage, including victims and massive destruction of properties. Conventional methods of firefighting put the firefighters at risk of exorbitant temperatures, poisonous fumes, and extreme threats.

The solution offered is a firefighting robot based on Arduino platform which can be operated manually or semi autonomously and has a water pump for moving as well as extinguishing fires. The military grade infrared cameras along with temperature and flame sensors are embedded in the robot to help find the source of fire with utmost accuracy. The robot is designed for both indoor and outdoor firefighting navigating controlled space with avoiding obstacles.

The robot assists firefighters in battling fire across different environment, enhancing safety and efficiency. Its small size enables it to reach places like chemical plants, industrial sites, and residential houses where human firefighters would be far too unsafe.

Remote monitoring also enhances operational effectiveness and safety: the robot thus furnishes the firefighters with the possibility of appraising situations from safer distances. Real-time detection and suppression of the fire by the robot, therefore, reduces response times which would in turn help curb the spread of the fire and damage that it causes. More operational effectiveness will be gained through lesser damage on some property-fires, where it would otherwise take a lot of time to get to the fire source; further, the robot will also keep the firefighters safe.

Plus, this approach is effective works wells , it speaks to human endurance limitations, as this robot can operate continuously without getting fatigued. This aspect of technology proves highly reliable for missions that run for prolonged periods such as fire fighting, even on the limits of hazardous conditions with toxic gases or unstable structures. Hence, there will be no need for human presence as a life-taking factor.

Cost-effectiveness and accessibility are the major considerations in the design of the robot so that it can be employed in any industrial setup, disaster management authorities as well as fire departments. The design is made scalable and adaptable based on Arduino so that it can be further improved and modified in the future.

One of the biggest challenges in fire safety is the lack of immediate response. Fire indicates often worsen due to absence of early detection system or automated suppression mechanism. Even after fire alarm go off, the time it takes for responders to reach the scene gives the fire a chance to spread rapidly.
To tackle these challenges, we need an intelligent, automated system that can detect fire and dangers gases in real time response instantly, offers remote control and monitoring. To overcome these issues the ‘Spark Suppressor’- an IOT- enabled fire-fighting robot-offers a smart and efficient solution.

In short, the robot fire-fighter introduces new ways of managing fires by offering a solution that is dependable, safe and works automatically. The sensors, path finding algorithms, and great feature of being able to find and put out fires with very minimal human intervention could mean a break-or-make solution against fatalities, property loss, and general improvement in fire-quenching efficiency.

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3. Literature Review

Several research studies have explored the application of IoT in fire detection and suppression systems. Traditional fire alarms and smoke detectors provide only passive alerts, requiring human intervention. However, modern robotic systems integrate **real-time sensors, automation, and remote monitoring**, making firefighting more efficient.

Past studies on fire-fighting robots focus on different control mechanisms, such as **autonomous navigation, AI-based fire detection, and wireless communication technologies**. Our approach builds upon these concepts by integrating **IOT-based control, real-time monitoring, and an automated suppression system**, making it more effective for residential and industrial applications.

The evolutions of fire detection and suppression system have brought remarkable advancements. Traditional fire detection system only provide passive warning, requiring human involvement which may show slow response time and increase danger. With the integration of **automation and IoT**, smart fire-fighting robots have emerged, significantly improving response time and efficiency.

Research studies have shown that **IOT-based robotic systems** can significantly improve fire detection and suppression. For instance, past studies have focused on **wireless sensor networks, AI-based fire detection, and autonomous robotic navigation**. A study on **robot-assisted firefighting systems** highlighted the importance of real-time monitoring and automated fire suppression. The incorporation of **cloud computing and remote control systems** has further improved the effectiveness of firefighting robots.

Our approach capitalizes on these achievements by combining a **smart fire-fighting the robot with remote operations, real-time monitoring and automatic suspension**. Unlike conventional firefighting system, the spark suppressor delivers enhanced efficiency, flexibility and safety making it suitable for residential and commercial application.

4. Methodology

Building the firefighting robots involves a systematic process with multiple phases including Software integration, hardware assembly, testing and final deployment. The robot operates on Ardunino platform, combining sensors, actuators, and advanced control algorithms for precise fire detection and extinguishing.

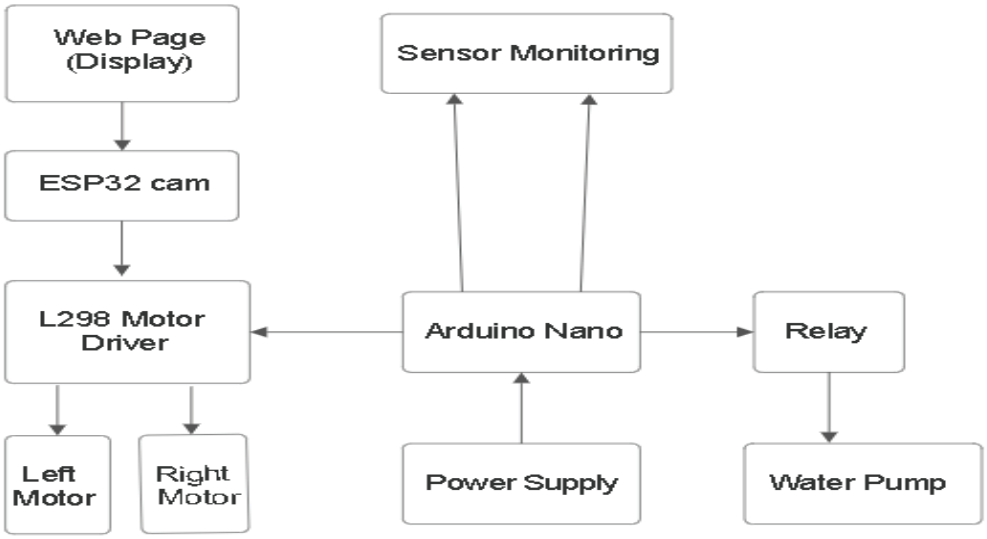

Figure 4.1 Prototype

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4.1 Components Used

- **Microcontroller:** Arduino Nano (processes sensor data and controls actuators).
- **Sensors:**
  - **Flame Sensor:** Detects fire and activates the water pump.
  - **Gas Sensor (MQ2):** Detects harmful gases and triggers an alarm.
- **Motor Driver (L298):** Controls six motors for movement.
- **Relay Module:** Controls the water pump.
- **ESP32-CAM:** Provides live video streaming.
- **PCB Board:** Connects all components in a stable circuit.

4.2 Software Used

- **Programming Languages:** C, C++ (for Arduino and ESP32-CAM).
- **Local Host Website:** HTML, CSS, JavaScript (for controlling the robot).
- **IoT Integration:** Used for remote monitoring and sensor data transmission.

4. Working Mechanism and Project Flow

4.1 Mechanism

- **Fire Detection & Suppression:**
  The flame sensor detects fire and sends a signal to the Arduino Nano.
  The relay module activates the water pump to sprinkle water and extinguish the fire.

- **Gas Detection & Alert System:**
  The MQ2 gas sensor detects harmful gases.
  If gas is detected, the buzzer is activated every 20 seconds.

- **Robot Movement:**
  Controlled through a local web interface (forward, backward, left, right).

- **Live Monitoring & Control:**
  ESP32-CAM provides real-time video streaming.
  The web interface allows users to toggle the camera light on/off.

4.2 Project Flow

- Sensors continuously monitor fire and gas presence.
- If fire is detected, the pump is activated.
- If gas is detected, a buzzer sounds every 20 seconds.
- The robot can be manually controlled via a web interface.
- Live streaming allows real-time monitoring and intervention.

5. Embedded System Setup

The system is built on an **Arduino Nano microcontroller**, which processes data from sensors and controls robot movement. The **ESP32-CAM** handles live streaming, while the

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PCB board ensures all components are interconnected. The **motor driver** enables movement, and the **relay module** switches the water pump on and off. The local web server provides an easy-to-use interface for controlling the robot remotely.

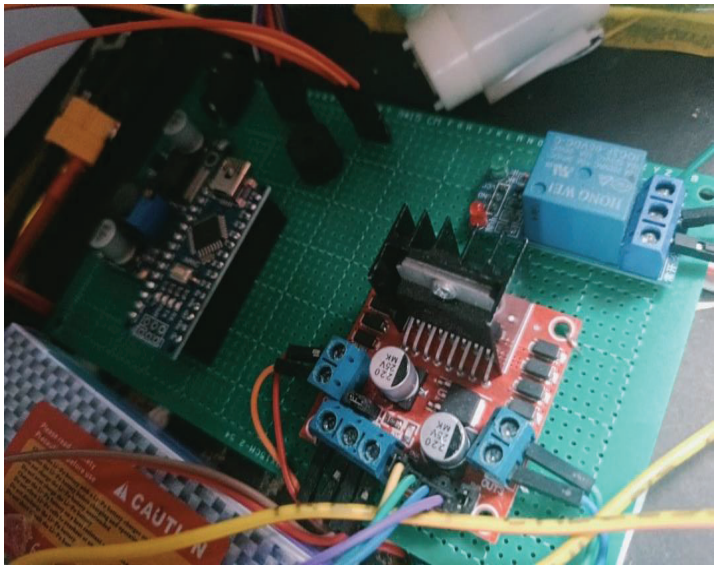

Figure 5.1 Internal Wiring

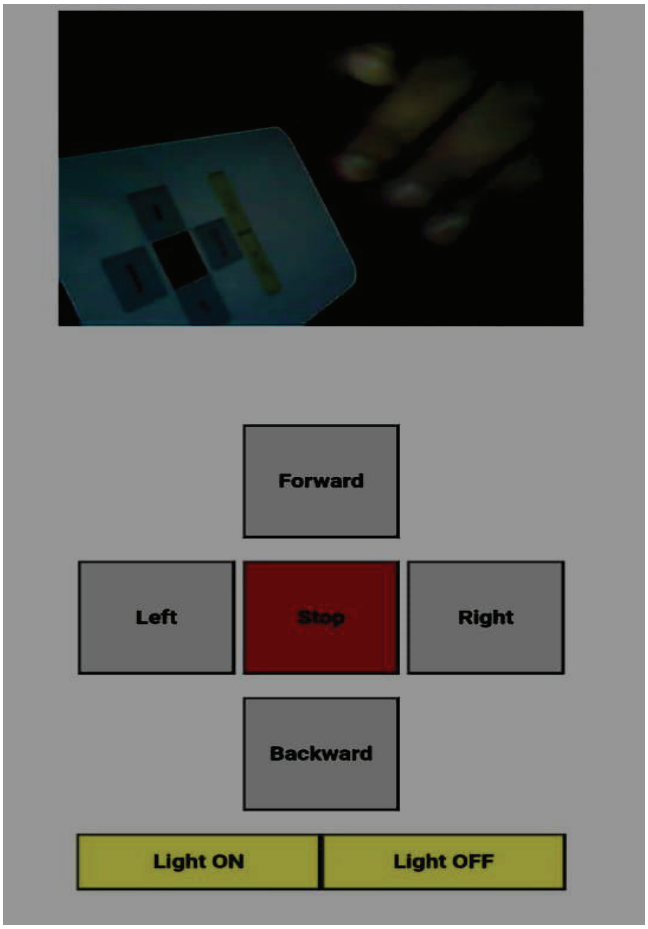

Figure 5.2 Interface

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6. Results

The **Spark Suppressor** successfully detects fires and gas leaks, responding automatically and remotely. Key observations include:

- **Fast fire suppression:** Water pump activates immediately when fire is detected.
- **Efficient gas detection:** The buzzer alerts users about harmful gases.
- **Smooth robot navigation:** Remote control via the web interface works seamlessly.
- **Real-time monitoring:** Live streaming allows users to monitor fire conditions remotely.

7. uture Scope

Future enhancements can include:

- **AI-based fire prediction** for early warning systems.
- **Autonomous navigation** for self-movement in complex environments.
- **5G and cloud connectivity** for better remote access.
- **Integration with fire departments** for emergency alerts.
- **Drone-assisted fire monitoring** for large-scale disaster management.

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